Advanced Space Transportation Technology Summary

Fission Propulsion

Fission – the release of large amounts of energy from the splitting of atomic nuclei – is one of the advanced concepts NASA's Marshall Space Flight Center in Huntsville, Ala., is exploring as a possibility for deep space travel. In contrast with conventional rockets that get their power from chemical reactions, future spacecraft could use fission to energize propellant.

Extraordinary energy is required to send spacecraft to other planets and destinations within and beyond our solar system. Current systems have essentially pushed chemical rockets to their performance limits. The energy density of fission is 10 million times that of chemical reactions, such as the liquid oxygen/hydrogen combustion used to power the Space Shuttle. Applying fission to a soda can full of uranium – about two pounds – could produce as much energy as 100 Shuttle External Tanks, or 52 million gallons (196.8 million liters) of liquid oxygen and hydrogen propellants.

Fission propulsion was worked on intensely during the Apollo years. In its current form, fission propulsion could be used to transport humans to Mars or send sophisticated robotic probes into the outer reaches of the solar system and beyond. More advanced versions of this technology could pave the way for rapid transit to any point in the solar system – a sheer impossibility with today's chemical rockets. A trip to Mars could take less than three months; a journey to Jupiter could be completed in less than one year. In its most advanced forms, fission could be used to extend human presence into the outer solar system and to conduct missions into interstellar space. Unlike other advanced non-chemical energy sources, fission is well understood and has no fundamental scientific issues preventing its immediate use.

A well-designed fission propulsion system would be relatively inexpensive to build. Systems could be designed to operate for only a few hours or up to 20 years, depending on mission requirements.

The fission process would initiate in space with the splitting of uranium fuel into two or more elements, resulting in liberation of tremendous amounts of energy. The fuel is non-radioactive throughout pre-launch activities and launch itself, and does not begin accumulating radioactive material until it is started up in space. For first-generation systems, the core could be as small as 16 inches (40.6 centimeters) in diameter and about 20 inches (50.8 centimeters) long. It could consist of fuel cylinders about one-half inch (1.27 centimeters) in diameter encased in tungsten, a metal used in electric lamp filaments. Small propellant passages and heat pipes surrounding each fuel cylinder would provide two modes of operation: a high-thrust mode where propellant is fed into and directly heated by the core, and a high-performance mode where the heat pipes provide the energy to power high-efficiency electric thrusters.

While fission systems that provide power to satellites have been flown by the U.S. and the former Soviet Union, fission has never been used in space for propulsion. Various government, industry and academic institutions have been developing fission technology for about 45 years, so NASA researchers have a good understanding of how the fuels burn and how materials behave during the fission process.

The research being conducted now at the Marshall Center will allow engineers to design and test an entire fission system without actually initiating fission. A small-scale laboratory experiment – called the Safe Affordable Fission Engine, or SAFE project – uses electrical resistance heaters to simulate the heat released from fission without use of uranium fuel. Tests are designed to provide important information on thermal and hydraulic characteristics of fission propulsion systems.

Fission propulsion is one of many technologies being explored by the Marshall Center's Advanced Space Transportation Program to pave the highway to space.

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